



Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

EROSION OF WATERSHEDS AND ITS PREVENTION

By BENJAMIN BROOKS¹

The problem of soil conservation on a watershed is like the problems of flood prevention, navigation and power development on a river. To be properly solved it must be studied broadly from the source down. Much more popular interest and support and much better results have been obtained by handling river navigation, flood prevention and power development together than by handling them separately, for they are all three related. But erosion of watersheds is first cousin to them all, and should be included in the discussion of the family affairs. It should be put on the list of natural resources to be conserved, for upon it we chiefly depend for our 300,000,000 square meals a day.

United States Army engineers have spent a great deal of money dredging harbors, removing sand bars and setting beacons for the sake of navigation. The mud they dug was of no interest to them. Other engineers have spent other large sums in chaperoning unruly rivers across the map so that they could successfully carry their silt along to fill up the harbors again. To them the mud was merely a menace to fill up their channels during low stages of the river so as to cause it to seek new channels during freshets.

In 1840 the Chemung River in New York appeared to an engineer who was born upon its banks, and was then six years old, as a clear, smooth stream with well-defined channel and firm grassy banks. Fifty years after, at the time of a freshet, it was scarcely recognizable. The banks were twice as far apart, the river was full of bars and had forsaken its proper course to tear up the crops and the property of the unhappy citizens who lived beside it. This old inhabitant blamed the wood cutters for this, without measuring the stream to find that no more water was going by than in his childhood and without stopping to consider that accurate gaugings for fifty years, on American rivers and for eight hundred years on the Danube show no general increase in floods throughout the whole process of

¹ Read at meeting of Illinois Section, January 25, 1916.

deforestation and civilization, that is, no general increase in the *amount* of water carried during floods, although the destructive effect of this amount has increased many fold. Why?

Very few engineers have followed this question properly to its source, nor regarded it as a sufficiently close relative to our other river questions, to solve it. One reason for this is that, as we approach the source of the difficulty, the problem frays out into countless separate little problems too small to interest the civil engineer or to pay him to solve. In fact, among older peoples, the solution is already well known. The chief difficulty in our new civilization is to get the old solutions applied. In the mountainous districts of the Philippine Islands, for instance, the savages, so called, although they have not yet discovered how to wear breeches, have developed a tremendous system of retaining walls and terraces so that entire flanks of the steepest mountains that would lie bare to the cloudburst and deluge in our states are brought under intensive cultivation despite a customary and frequent downpour of two feet of rain a day. In the Caucasus Mountains the inhabitants often use a similar system, and so well aware have they become of the value of soil that, if any escapes them, they descend to the valleys and carry it painstakingly back again in baskets on their heads.

In the uplands of the Carolinas and Georgia the farmers have been in business in one place long enough to realize that the light top soil which floats away from them so easily is their principal stock in trade and must be conserved. Through this district there is scarcely a hillside that is not completely terraced, the steps being maintained by stiff, thick, lowcut hedges which are not interfered with during cultivation. In this same district the Mangum terrace was invented, a low mound approximately following the contour, able to retain soil and prevent stream flow, but still allowing the agricultural machinery to pass over it. The inventor's detailed specifications for this kind of terrace are as follows:

Specifications

1. With transit, or farm level, lay out lines having a slope of about $1\frac{1}{2}$ inches in 14 feet. On very washy soils lessen this slope; on rather tenacious ones it may be slightly increased.
2. Space these lines at intervals of about 6 feet of fall, marking their courses with stakes or shallow furrows. They may thus come twenty paces apart, on steep land, or seventy-five or more on gentle declines.

3. With a two horse plow follow these lines, throw the furrows up hill below the line and down hill above it, so that the back furrow and the terrace line correspond in each case.

4. When a rain has settled the ground, repeat this process, or, better yet, use a drag scraper or shovels to throw the soil from the upper to the lower side of the terrace.

Thus the terrace is built, but it must be carefully watched for a few years and built up or smoothed over as conditions require, until it becomes permanent.

Coming now to a newer country nearer home, we can see the idea of soil conservation just beginning to take root. The writer has met and talked with some of the oldest farmer inhabitants along the south bank of the Missouri. Their farms lie in a hill country with very light soil some miles back from the main stream, but drained by small tributaries. These men have been through the whole gamut of experience, starting with smooth, grass covered farms, plowing the grass under, loosening the soil and having it wash away from them, leaving only deep ragged gullies and mortgages; then having to devise their own means of retaining what soil was left and refilling the gullies with it.

To accomplish this they worked on two main principles of soil conservation, which they discovered slowly but by bitter experience. They found out what every civil engineer knows, that running water caught in the act of robbing a farm of its soil, can be arrested in a pool long enough to drop its load and go on *empty handed*. Their method of arresting it is simply to throw earth dams at intervals across the gullies; but, in order that the dams shall not be overflowed and washed out, they provided each one with a bypass pipe underneath and a suitable riser made of ordinary clay sewer pipe, so that the water pooled and rose to the height of the bypass, dropped its soil, and ran off comparatively clear. As the gully filled up with this deposited soil, they raised the dam and added more sewer pipe to the riser until the entire gully became a flight of smooth terraces instead of a hole in the ground.

The other principle they discovered is also well known to us, the fact that water, soaking slowly down through soil and out through subdrains, will cause no erosion; while the same amount of water coursing over the surface will cause it. Accordingly, some of them laid clay drain tile along the bottoms of the gullies and filled in over them. Sometimes they combined the two ideas, throwing

low dams across the filled gullies and connecting a riser pipe with the drain below. They went so far as to get the county supervisors to allow them to take out their old wooden culverts which let soil and water alike go by, and to put in soil saving sewer pipes wherever a bad gully crossed a country road.

But these successful farmers are but a very few out of many. Everywhere one travels in the Mississippi Valley, by simply looking out of the car window in any county in any state, one sees innumerable places where farmers have tried to prevent this soil erosion by filling their gullies with tin cans, brush and unprotected mud dams. None of these crude attempts works. The soil keeps going.

Now here is the important and most regrettable point. Although these petty details on the farm can never each receive the individual attention of a life-sized engineer, still it is exactly from these innumerable small beginnings that the ruination of the continent—already said to have spread over three million square miles—begins. These are the little sources from which rivers receive the silt that lessens their depth, increases their width, spills their floods over valuable property and shoals the harbors. The source of the soil is not the source of the main rivers. The Missouri, the Platte, the Arkansas, the Red River are all comparatively clear streams near their sources, and receive their load of soil only when they reach plowed land. Old farmers have shown me tributary streams which used to be clear before they broke the soil, but which are now heavy with brown silt. There are old charts of San Francisco Bay and the testimony of old time yachtsmen still living to show that certain towns near the confluence of the two principal rivers of the state were once on navigable water although it is now impossible to get within a mile of them in a boat drawing three feet. This change is coincident with the cultivation of the broad valleys above. When the Phoenicians first landed at the eastern end of the Mediterranean they founded their cities on isolated rocks off shore. When the Israelites came to cultivate and plow the adjacent slopes, these cities became part of the mainland. Government reports, engineering reports, history and geography all contain copious proofs that agriculture is the chief factor in soil erosion, river clogging, flood increase and harbor shoaling.

But it will be a long time in this country before farmers generally will be driven by necessity to conserve their soil for its own sake. They will never do it for these other considerations of flood pre-

vention and navigation. We engineers will never have time to devote to each farm piecemeal. The matter must be handled in a more wholesale, inter-related way; and the object of this paper is principally to suggest two or three ways.

The United States government is already on the point of saying how much sewage a community may dump into a river on account of public health. Countless analyses have already been made along our principal streams in preparation for saying just this. Is it inconceivable that once having demonstrated to the right authorities where the soil comes from, the government, instead of appropriating millions of dollars to fix up temporarily a silt clogged river, might take account of the silt content in a certain tributary stream and compel every farmer on its water shed to take such precaution against soil erosion as to prevent it, or pay a fine for spoiling the public's navigable river.

Or take it in connection with floods. We all know that tile draining is something more than a quick way of shedding water. It will take the farmer, generally speaking, a long, long time to think of it as a means of improving his soil, of emptying it of surplus water and filling it with air without drying it, to his great benefit. But if we were to regard tile drainage on a large scale throughout wet lands as a means of making the entire floor of the Mississippi Valley into a storage reservoir three or four feet deep which could have no surface torrents rushing over it, but which would deliver water to the rivers at, say, half an inch each 24 hours, then the flood prevention commissioners might take notice and ultimately find a way to penalize a man who negligently stored a potential flood on his land. By such a stroke all three difficulties, soil erosion, navigation interruption and floods, could be overcome at once and on a large scale compatible with modern engineering.

Or take it again on the principle of public sanitation. While our American health boards and investigators have been studying various bugs, flies, germs and fungi to discover which is the cause of pellagra, that European scourge that is gaining so rapidly in this country, the University of Rome, after years of continued research, has definitely determined and proved that pellagra is caused by muddy water, by the erosion of agricultural soils containing colloidal silica. In New Hampshire, Nevada, Utah, Wyoming, and Minnesota districts free from clay muddied waters there is no pellagra. In the Carolinas, in Georgia, Missouri, Illinois, places

where the farmer turns the streams a rich chocolate color, there is an ever increasing and seriously menacing amount of it. To prevent soil erosion would eliminate one more hitherto invincible enemy of mankind.

The American farmer, no matter how little he reads or how heedless he may be of our individual suggestions, will finally come, through dire necessity, to the idea of conserving his soil just as the naked farmer of the Philippines has finally left off hunting the heads of his wife's relatives and taken to giant powder, rock drills, stone walls and terraces; but if our influential engineering societies can suggest strongly enough to our influential law makers how the important problem of soil saving may be connected to and handled with our other great national engineering problems, we may save a few generations of time and a great part of the arable continent.